Workshop on monitoring Ph.D. Students program
Ph.D. Program on Information and Communication Technology (Doc-TIC)
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INTERFERENCE AWARE RESOURCE ALLOCATION FOR UNDERLAY D2D-BASED DATA OFFLOADING IN 5G CELLULAR NETWORK

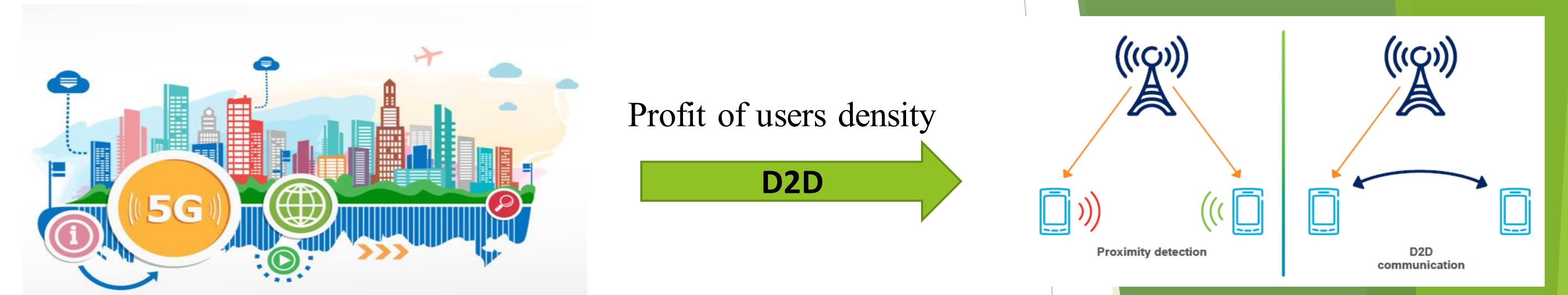Mariem Hmila, Supervised by Manuel Fernández Veiga
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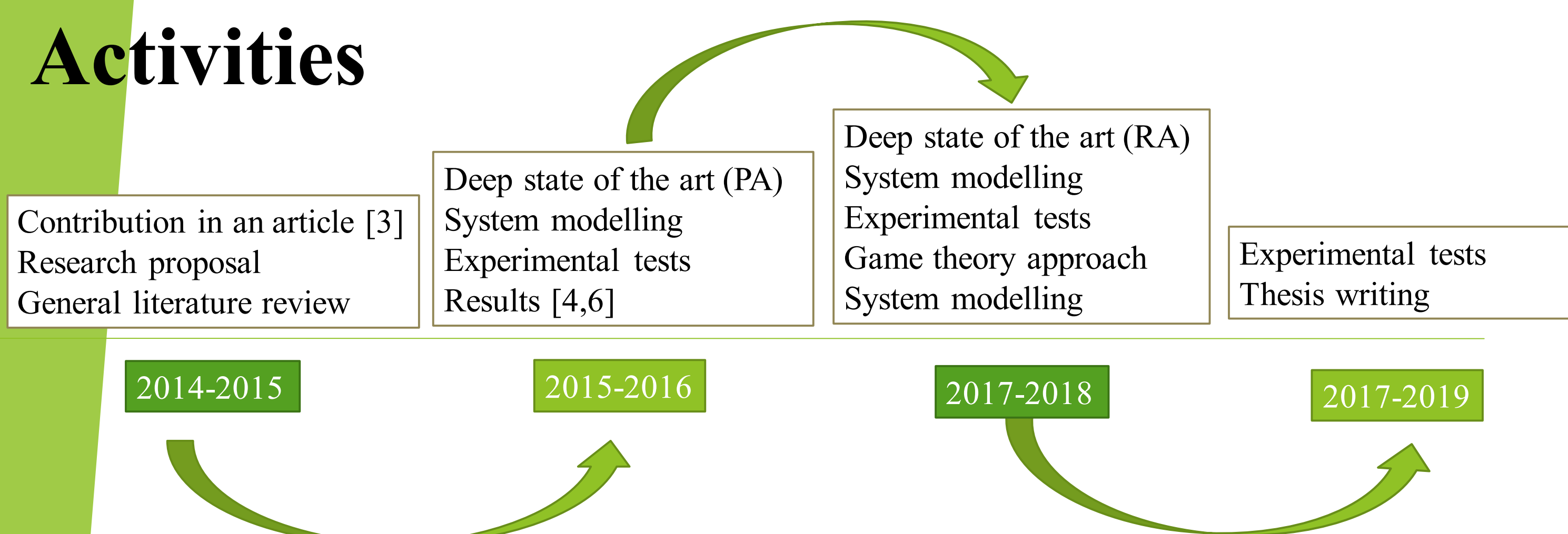
Motivation

☐ The 5G is a green cellular network aims to have 1000x higher data volume, up to 100x more throughput and connected devices, and low latency while maintaining moderated energy consumption levels.

❑ Underlay device-to-device communication (D2D) is a new paradigm introduced to realize 5G. It allows users in close proximity to communicate directly without the intervention of the base station using resource blocks already allocated to cellular user. This increases network capacity, spectral and energy efficiency but it causes harmful interference to cellular users. Moreover, these devices have limited life battery [1].

☐ Our main interest is underlay device to multi device (D2MD), here devices form a cluster/group with one device as head cluster for data offloading . This model inherit single transmitter to single receiver (unicast) challenges and poses more as: weakest receiver, head cluster selection, and users grouping. These points are poorly addressed in the literature compared to unicast cases and need more investigation [2,4].

Objectives

Our main objective is the application of underlay multicast D2D communication for data offloading in 5G cellular networks. Mainly, we focus on providing low complexity algorithms for relay selection, resource allocation, and devices clustering. We intend to use optimization techniques and game theory to model and solve these problems considering energy consumption reducing and interference mitigation. Moreover, we will apply an experimental methodology that combines theoretical analysis with extensive simulations.
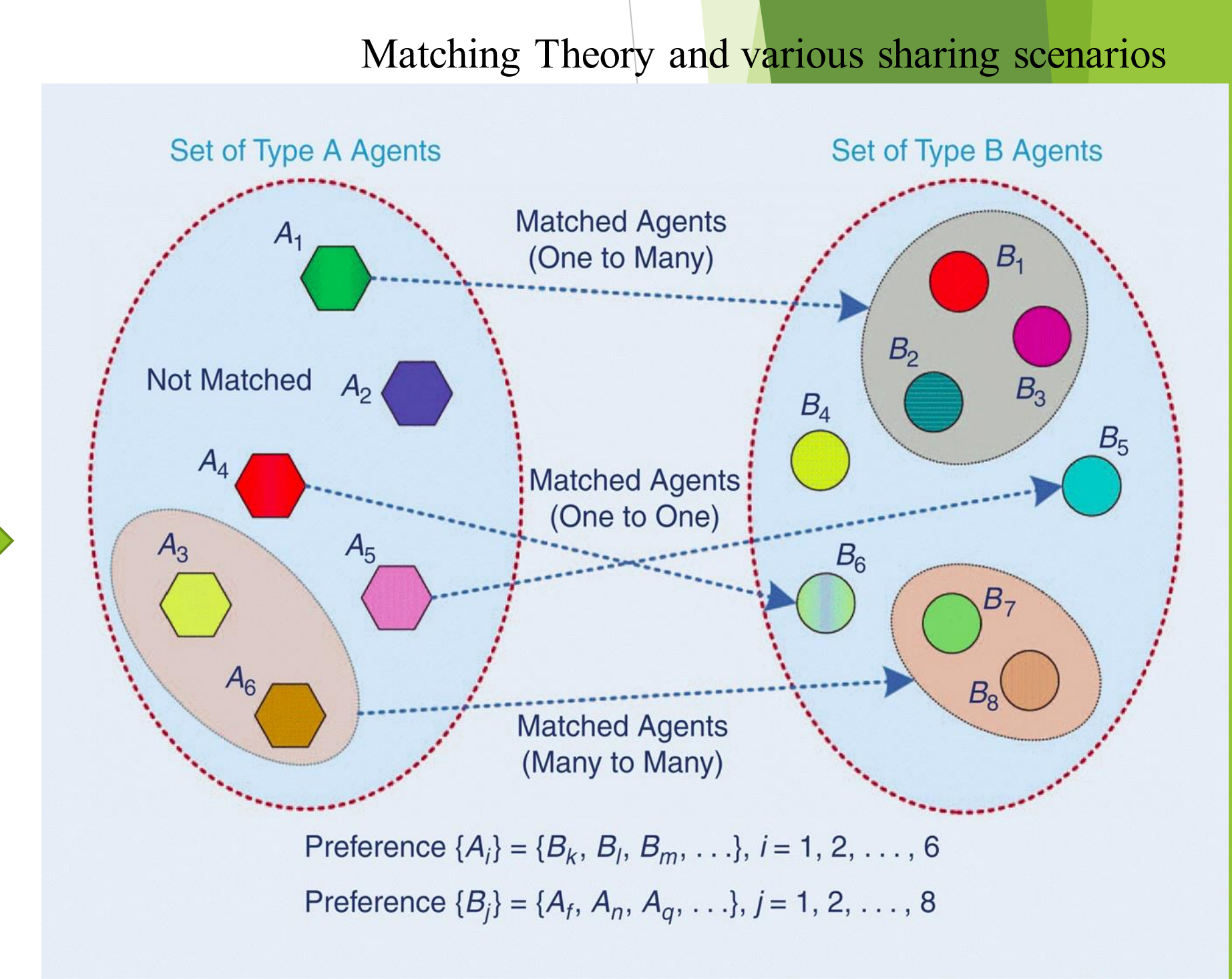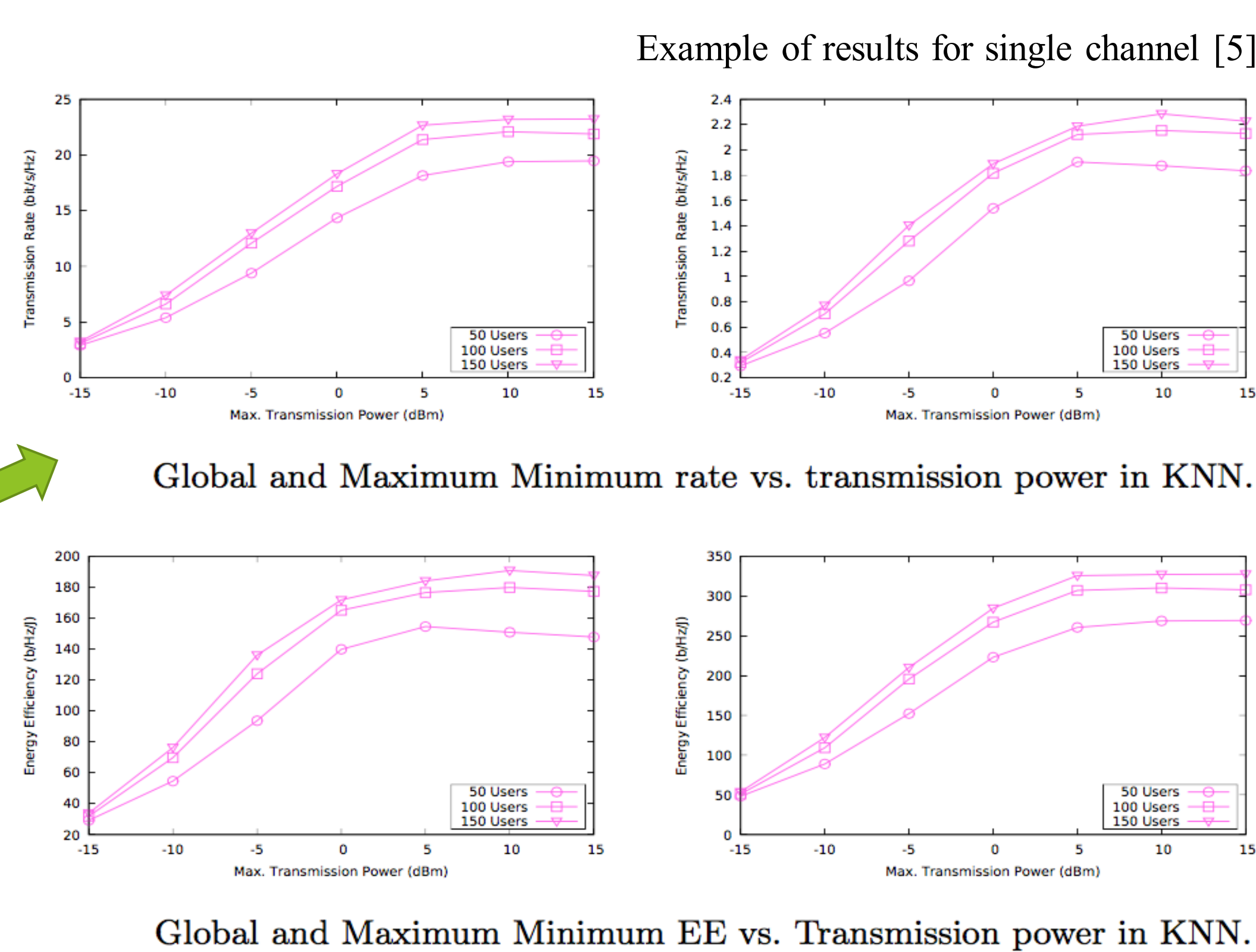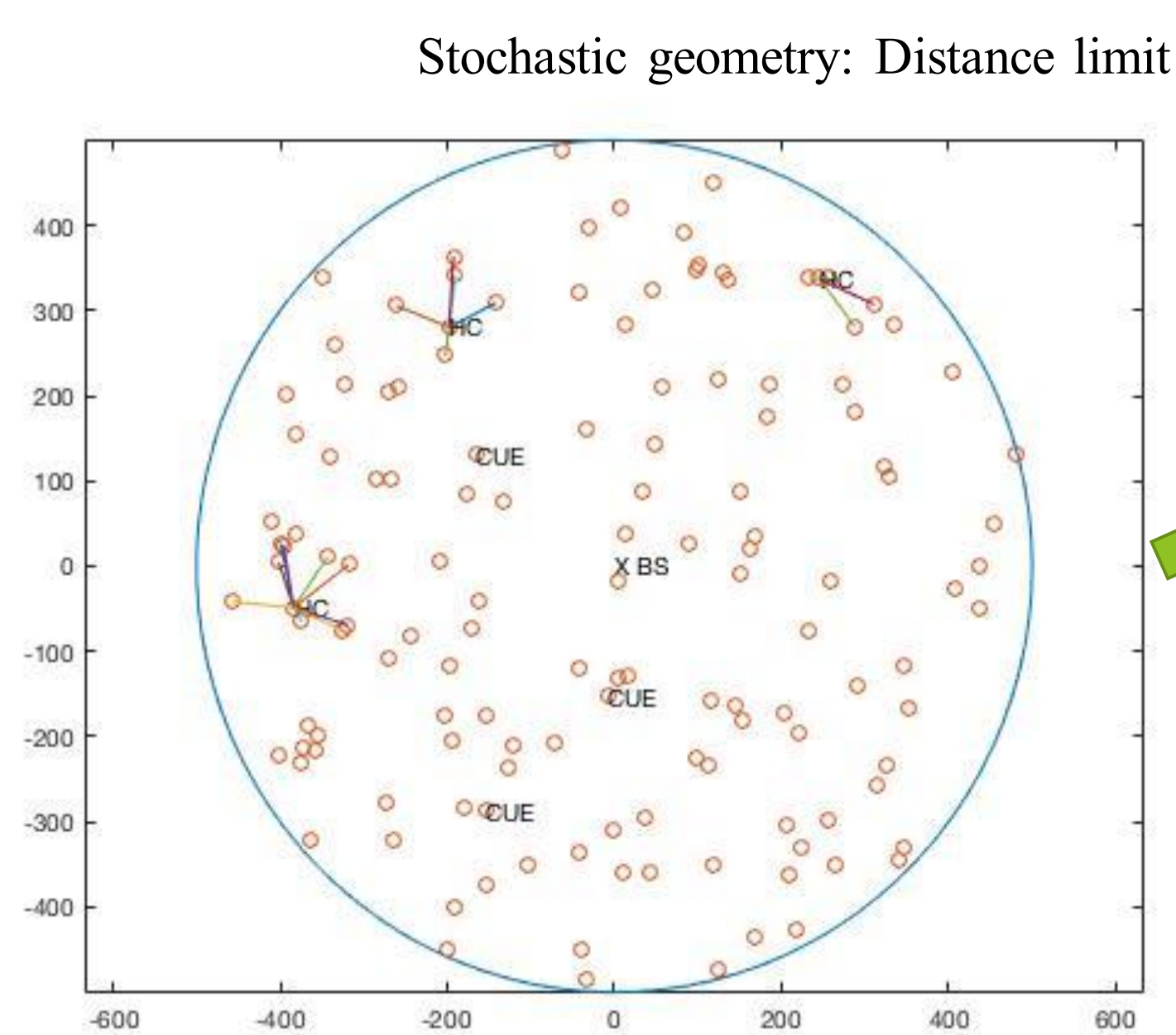

Activities

Contribution in an article [3]
Research proposal
General literature review

Deep state of the art (PA)
System modelling
Experimental tests
Results [4,6]

Deep state of the art (RA)
System modelling
Experimental tests
Game theory approach
System modelling

Experimental tests
Thesis writing

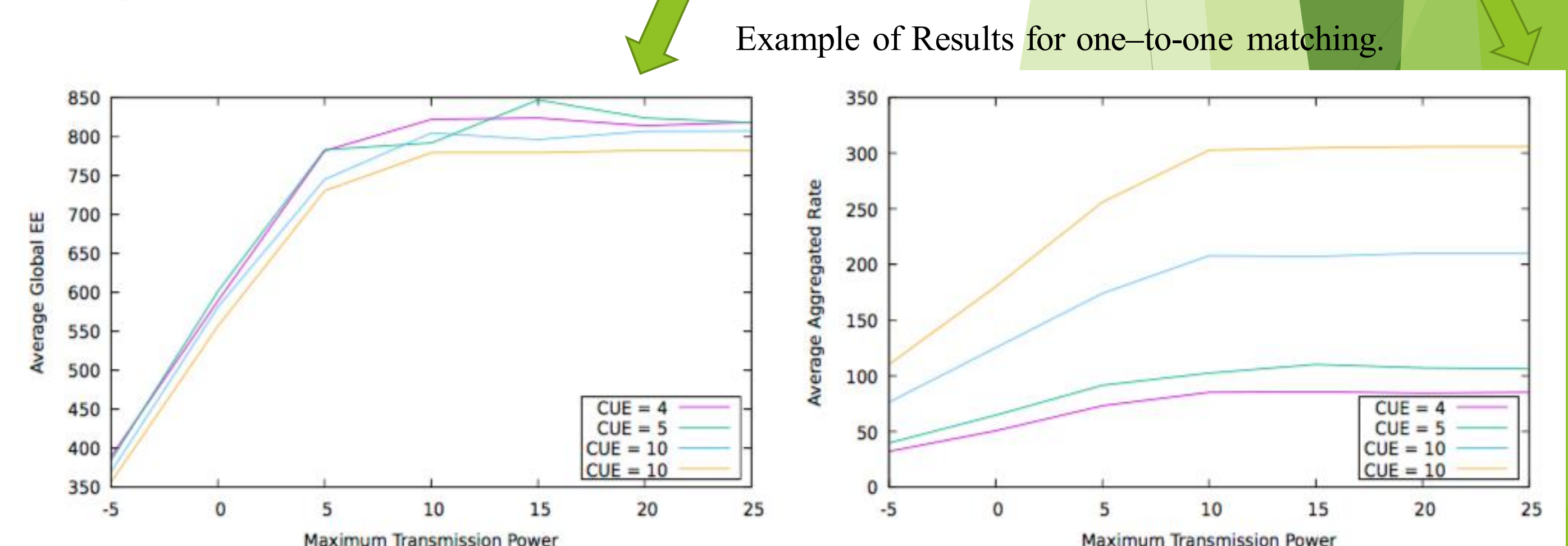2014-2015   2015-2016   2017-2018   2017-2019

Research Plan

1) Literature review and knowledge about the field (5G cellular network, D2D communication, data offloading) and challenges definition.
2) Literature review and knowledge about interference management, resource allocation, D2D communication in data offloading.
3) Deeply investigate cooperative offloading to define novel and efficient criteria for:
        a) Power allocation (PA).
        b) Resources allocation (RA).
        c) Devices grouping and relay selection.
4) Use optimization techniques and game theories and models to formulate the previous problems.
5) Design and implement new algorithms to solve the previous problems.
6) Evaluate our approaches with extensive simulation.
7) Publish our results in international workshops, conferences, journals.

Results and Discussion

Stochastic geometry: Distance limit

Example of results for single channel [5]

Global and Maximum Minimum rate vs. transmission power in KNN.

Global and Maximum Minimum EE vs. Transmission power in KNN.

Matching Theory and various sharing scenarios

Preference $\{A_i\} = \{B_k, B_l, B_m, \ldots\}, i = 1, 2, \ldots, 6$
Preference $\{B_j\} = \{A_f, A_n, A_q, \ldots\}, j = 1, 2, \ldots, 8$

Example of Results for one–to–one matching.

Global EE, Aggregated Rate for One-to-One Matching Case

1) We modeled the system as joint power and resource allocation problem and analyzed its complexity.
2) We proposed centralized resource and power allocation schemas to evaluate network and devices EE (Global and Minimum).
3) We used stochastic geometry to simulate two devices clustering techniques: K-nearest neighbor, distance limit.
4) Using matching theory and three difference allocation algorithms, we investigated problem feasibility in different resource sharing scenarios: one-to-one, many-to-one and many-to-many.
5) We proposed a distributed solution using overlapping coalition formation model.
6) To compare between centralized and distribution solutions, we repeated the resources sharing scenarios empowered by stochastic geometry to investigate EE.
7) We have identified the capacity region of D2MD.
8) D2MD improves EE over simple D2D.

Next Year Plan

2) Complete evaluating the models experimentally (via simulation).
3) Publish results in conferences and journals.
4) Write and defend the thesis.

References

[1]Song, L., Niyato, D., Han, Z., & Hossain, E. (2015). Wireless Device-to-Device Communications and Networks. Cambridge University Press.
[2]Bhardwaj, Ajay, and Samar Agnihotri. ―A resource allocation scheme for device– to—device multicast n cellular networks.‖ Personal, Indoor, and Mobile Radio Communication (PIMRC),2015 IEEE 26th Annual International Symposium on. IEEE,2015.
[3]Rodriguez-Perez, Miguel, et al. ―Optimum Traffic Allocation in Bundled Energy-Efficient Ethernet Links. ‖ IEEE (2015).
[4]Militano, Leonardo, et al ―When D2D communication improves group oriented services in beyond 4G networks.‖ Wireless Networks 21.4 (2015):1363-1377.
[5] M. Hmila and M. Fernández Veiga "Energy-efficient Power Control and Clustering in Underlay Device to Multi-Device Communications" ‖ WWIC 2017
[6] M. Hmila and M. Fernández Veiga "Analysis of Optimal Power Control and Energy Efficiency in Multicast D2D Communications" ‖ ICCCS 2017